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# The role played by education in the decision to smoke and tobacco consumption intensity: evidence from Brazil

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**Abstract**

We investigated the role played by education in the decision to smoke and tobacco consumption intensity, controlling for socioeconomic and demographic characteristics, among other relevant variables. A random sample composed of almost 36,000 people living in Brazil was used. We found that higher levels of education are associated with a lower probability of smoking and with a lower number of cigarettes smoked daily. This result, however, was more pronounced for men as compared to women.

*Keywords:* Smoking; tobacco; addiction; human capital; health
*JEL classification: I12, D12, C50*

## 1. Introduction

Smoking is a toxicomania characterized by physical and psychological addiction to nicotine, one of the 4,720 toxic substances contained in tobacco. Research associates smoking with at least fifty types of diseases, most of which are chronic and severe ones. It is estimated that the life expectancy of a smoking individual is at least 10 years shorter than that of a non-smoking one.

In Brazil, tobacco use often takes the form of consumption of manufactured cigarettes. In 2013, there were 21.4 million smokers in Brazil, 18.5 million of whom were daily smokers. According to the Ministry of Health, about 200,000 deaths per year are related to tobacco consumption.

In economic terms, smoking increases expenditures with health care and decreases productivity due to morbidity and premature death, substantially reducing the stock of human capital in society (World Bank, 1999). According to estimates of World Bank (2015), when

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indirect costs are also taken into account, smoking accounts for losses estimated at US$ 1 trillion worldwide every year. The World Health Organization (WHO) considers smoking as the main cause of preventable death in the world.

In view of the great social impact of smoking, this paper is mainly intended to empirically investigate, based on Becker and Murphy (1988) theory of rational addiction, the socioeconomic and demographic risk factors associated with tobacco consumption and intensity of tobacco use, emphasizing the hypothetical effect of education. What socioeconomic characteristics are associated with the decision to smoke and with the intensity of tobacco use? Since education is positively associated with an individual's health status and habits (Cutler and Lleras-Muney, 2006; Deaton and Paxson, 2004; Grossman, 2006; Lleras-Muney, 2005), is the same reasoning valid for the relationship between education and smoking behavior?

The theory of human capital and the relationship between education and health can explain the link between education and decisions related to smoking. Becker (1962) defines investment in human capital as one of the activities leading to a higher real income in the future for an individual. This investment includes schooling, professional training, health care and acquisition of information about the economic system. All investments of this kind in human beings could improve their physical and mental skills, making it possible to predict with greater certainty that their real income will be higher in the future. Workers can invest in any aspect that can enhance and improve their skills (schooling and/or training), thus improving their human capital and consequently raising their marginal productivity and earnings in the labor market.

For Schultz (1961) much of what we consider consumption is actually investment in human capital: spending on education, health care, internal migrations in search of better job opportunities, among other expenditures. By investing in themselves, individuals can expand the set of choices available to them, increasing their well-being.

Galama and van Kippersluis (2015) mention the importance of health care as an element of human capital: longevity, provision of direct utility and time that can be devoted to working. Theory describes the persistent association between education and health in several ways. There is evidence that education increases access to important information for people to consider health care when making decisions, i.e. education paves the way for different patterns of reasoning and decision-making. In general, more educated people respond to new information faster than less educated or uneducated individuals. Education also affects health through changes in behaviors and opportunities, particularly in income opportunities (World Bank, 1999; Cutler and Lleras-Muney, 2006; de Walque, 2010; Feinstein, 2002; Grossman, 1972).

As education affects health-related decisions, it is also likely to affect decisions related to smoking. Several studies have shown that this relation is real. Their results suggest that education can affect the decision to quit smoking and that more education reduces smoking initiation and addiction to nicotine. Indirectly, if education makes people more patient, it reduces their propensity to indulge in short-term pleasures with long-term costs (de Walque, 2010; Kendler et al., 1999; Koning et al., 2015; Sander, 1995).

In this theoretical context, we apply two hypotheses. The first one is that "*education reduces the probability of an individual becoming a smoker*", and the second one is that

"*education reduces the intensity of tobacco use among smokers*". Therefore, we used a large random sample of Brazilians aged 15 and above composed of almost 36,000 people from all over the country. We highlight that microdata of this nature is rarely found even in developed countries, where data for empirical research are more available. However, only de Almeida and de Araújo Júnior (2017) have explored this data set for identifying the effect of tobacco use on wages so far.

The main contribution of this paper is to show the relationship between education and smoking in Brazil. According to Grimard and Parent (2007), the link between education and smoking may be due to better use of information about the risks of smoking behavior. We therefore explore this mechanism based on the interaction between knowledge of smoking risks and education. We also take into account gender differences and the fact that the majority of smokers started smoking at a young age. This strategy allows us to investigate how education is related to the status of being a smoker at the present time for Brazilians.

This study is organized as follows. We present some relevant previous empirical studies in Section 2. In Section 3 we show the data base, the modelling and the specification of empirical models. In section 4 we discuss the results. Section 5 concludes the paper.

## 2. Previous Empirical Studies

The empirical literature suggests that the effects of education on health occur through three channels: (i) economic factors such as income and employment; (ii) health-related behaviors and (iii) psychosocial factors. In this paper, we will analyze the effects on health-related behaviors. These behaviors include, among others, the habit of smoking, which is the subject matter of this study.

The strong relationship between education and health, even controlling for income, is considered robust in the literature on social sciences and economics (Deaton and Paxson, 2004; Fuchs, 1982; Grossman, 2004; Lleras-Muney, 2005). The decision to smoke or not is a conscious choice that has a direct bearing on an individual's health status and mortality. Because smoking is the leading cause of preventable death in the world, the fact that education may play a major role in preventing this habit suggests that traditional estimates of the returns on education, which are often focused on results for the labor market, may perhaps underestimate actual returns. Since education affects health-related decisions, it is also likely to affect decisions related to smoking. Results show that education can affect the decision to quit smoking and that more schooling may be associated with lower tobacco use initiation rates and lower nicotine addiction rates.

Wetter et al. (2005) observed a strong relationship between lower schooling and greater likelihood of smoking, since less educated people tend to work in environments in which smoking is acceptable and where there is little incentive to quit smoking. De Walque (2007) found the result that more educated people are less likely to smoke and, when they do smoke, they are more likely to quit. Grimard and Parent (2007) also observed the effect of education on starting to smoke, but they found no evidence that more educated individuals are more likely to quit smoking. For Brazil, there is some evidences that tobacco addiction is prevalent among less educated and lower-income groups IBGE (2014); Pinto and Ugá

(2010). It should be highlighted there are only a few studies which did not detect the effects of education on tobacco use (Tenn et al., 2010) and on the decision to start smoking (Koning et al., 2015) or which found a nonlinear relationship between smoking and years of schooling (Zhu et al., 1996).

Government policies that affect smoking behavior also have major implications for public health, economic efficiency and government revenue goals. According to Keeler et al. (2001), the most important of these policies is that of taxing tobacco, through which two objectives can be achieved simultaneously: those of reducing tobacco consumption and of increasing government revenues. However, there are many other studies that analyze the effects of other government policies on smoking, such as anti-smoking regulations, educational campaigns and, less obviously, schooling, which has been found to reduce tobacco use and stimulate healthy behaviors. Table 1 shows some results of previous studies on the relationship between education, health and smoking.

Table 1: Selected studies on the effects of education on health and smoking

| Authors | Objective | Data | Results |
|---|---|---|---|
| Cutler e Lleras-Muney (2006) | To estimate the effects of education on health behavior and its quality. | *National Health Interview* Survey, conducted in the United States. Individuals aged 25 or over. | Education can affect health by improving one's reasoning and decision making. |
| De Walque (2010) | To test the hypothesis that education improves health and increases life expectancy. | 16 supplements about smoking of the National Health Interview Survey, between 1978 and 2000. | With warnings about the dangers of smoking, smoking prevalence among the most educated fell more quickly. |
| Feinstein (2002) | To estimate the effects of schooling on two important aspects of health: depression and obesity. | United Kingdom National Cohorts. People surveyed in 1999/2000. | Education can affect health both directly, by changing behaviors and/or preferences, and indirectly, through changes in opportunities, particularly in income opportunities. |
| Grossman (1972) | To build a model of positive demand for the health commodity. | – | Education increases access to important information for people to consider health care when making decisions. |
| Kendler et al. (1999) | To investigate the relationship between the risk factors for smoking initiation and dependence. | Personal interview with twin women from the Virginia Registry in 1898. | More years of schooling are associated with a reduction in smoking initiation and nicotine dependence. |
| Koning et al. (2015) | To analyze the effects of education on decisions of start or quit smoking. | Longitudinal data for Australian twins (1980-1982 and 1988-1989). | Schooling does not affect the decision of start smoking, but has significant effect on the decision to quit smoking. |
| Welte et al. (2000) | To investigate potential years of lost lifetime, direct medical costs and indirect costs ofsmoking | *Statutory Health Insurance* Data; German Federal Statistical Office | Smoking accounted for 23% of deaths among men and for 5% of all deaths among women, as well as for the potential loss of 1.5 million years of lifetime. |

Source: Prepared by the authors.

## 3. Methodology

### *3.1. Data and sample*

We use data from the Special Survey on Tobacco Addiction (PETab, in the Brazilian acronym) that was jointly carried out with the 2008 National Household Sampling Survey (PNAD, in the Brazilian acronym). The survey was conducted through a partnership between the Brazilian Institute for Geography and Statistics (IBGE, in the Brazilian acronym), the Ministry of Health, the National Cancer Institute (INCA, in the Brazilian acronym), the Health Surveillance Secretariat (SVS, in the Brazilian acronym) and the National Health Surveillance Agency (ANVISA, in the Brazilian acronym).

The data was collected from a sub-sample of households surveyed through the PNAD 2008, covering individuals aged 15 and above in about 51,000 Brazilian households. The individuals included in that sub-sample answered questions related to the use of tobacco products, to their attempts to quit smoking, to their exposure to smoke and to their access to awareness-raising campaigns and to information on the risks of smoking, among other issues related to the main topic. For other people interviewed through the PNAD 2008, information is only available for the habit of smoking, type of tobacco product used and amount consumed.

It should be noted that the PETab survey is carried out in Brazil as part of an initiative of the World Health Organization (WHO) and of the Centers for Disease Control and Prevention. This partnership was established with the aim of promoting part of a survey conducted in 14 countries, including Brazil, entitled Global Adults Tobacco Survey (GATS)[5].

Table 2 shows the variables selected in the PETab survey to be used for modeling the decision to smoke and the intensity of cigarette consumption. These characteristics were chosen based on the theoretical and empirical literature cited in the 2 section.

The individual characteristics that we used included indicators for males, race/color, current work status, age bracket and per capita household income. As for geographic characteristics, we included dummy variables for urban area and metropolitan region. We believe that cigarette consumption is higher in those areas, since in rural areas, for example, chewing tobacco or consuming cigarettes other than manufactured cigarettes are more common. We also included dummies to capture the diversity of Brazil's regions. In this case, consumption is expected to be higher in Brazil's south region, as this region accounts for about 98% of all the tobacco produced in Brazil.

Moreover, it was also possible to build variables to indicate whether the individual had access to information of some kind about the potential risks of smoking and whether he or she had been exposed to any cigarette ads. The former, called Warning, is a binary variable that takes value 1 if the individual is aware of at least one of the following risks: cigarette smoke causes serious illnesses, smoking causes serious illnesses, smoking causes heart diseases, smoking causes lung cancer, and using smokeless tobacco causes serious

[5]That survey is intended to improve the capacity of countries to design, implement and evaluate tobacco control programs.

illnesses. The latter, called Marketing, is a binary variable that takes value 1 if the individual was exposed to cigarettes ads in any type of media.

Furthermore, since all PNAD respondents also answered a question about whether they used tobacco or not, we computed the percentage of smokers in the households (Smokers [%]). It's important to highlight that the respondent was excluded from the calculation of the percentage of smokers in the household.

It is noteworthy that we chose to use education level than years of schooling in the modeling to measure human capital. Our objective in this case was to check for any non-linearity in the relationship between education and smoking, as in the relationship found by Zhu et al. (1996). It is to be expected that more educated individuals are better prepared to evaluate the costs and benefits of smoking.

Table 2: Definition and statistical summary of the variables used in the empirical models

| Variable | Definition | Mean | Std. Dev. |
|---|---|---|---|
| `No schooling` | 1 if the individual has no education and 0 otherwise | 0.113 | 0.317 |
| `Elementary or less` | 1 if the individual did not complete primary education 0 otherwise | 0.352 | 0.478 |
| `Primary education` | 1 if the individual completed elementary school and 0 otherwise | 0.179 | 0.384 |
| `High school` | 1 if the individual completed high school and 0 otherwise | 0.271 | 0.445 |
| `Higher education` | 1 if the individual is a college graduate and 0 otherwise | 0.084 | 0.277 |
| `Income (ln)` | Logarithm for household income *per capita* | 6.016 | 1.014 |
| `Works` | 1 if the individual works and 0 otherwise | 0.665 | 0.472 |
| `Young` | 1 if young individual (from 15 to 29 years) and 0 otherwise | 0.311 | 0.463 |
| `Adult` | 1 if adult individual (from 30 to 59 years) and 0 otherwise | 0.532 | 0.499 |
| `Elderly` | 1 if elderly individual (60 years of age or older) and 0 otherwise | 0.157 | 0.364 |
| `Man` | 1 if the individual is male and 0 otherwise | 0.457 | 0.498 |
| `White` | 1 if the individual is Caucasian or Oriental and 0 otherwise | 0.471 | 0.499 |
| `Householder` | 1 if the individual is the family head and 0 otherwise | 0.517 | 0.500 |
| `Smokers (%)` | Percentage of smokers in the household | 0.063 | 0.140 |
| `Warning` | 1 if the individual is aware of the risks of tobacco addiction and 0 otherwise | 0.970 | 0.172 |
| `Marketing` | 1 if the individual saw cigarette ads and 0 otherwise | 0.397 | 0.489 |
| `Urban` | 1 if the individual lives in an urban area and 0 otherwise | 0.850 | 0.357 |
| `Metropolis` | 1 if the individual lives in a large city and 0 otherwise | 0.376 | 0.484 |
| `Cigarettes smoked` | Amount of cigarettes smoked in a day | 1.961 | 5.190 |
| `Cigarrete (if smoker)` | 1 if the individual smokes manufactured cigarettes and 0 otherwise | 0.837 | 0.369 |

Source: Prepared by the authors using data from the PETab survey ($n$ = 35,601).

Table 3 presents a descriptive analysis for the group of non-smokers, smokers, ex-smokers and those who made an attempt to quit smoking. This analysis shows that ex-smokers are different from non-smokers mainly with regard to age. The difference between smokers and those who attempted to quit smoking are not so clear. But we can at least infer that there is a difference in non-observable characteristics, i.e. the health status of those who made an attempt to quit smoking may be worse than that of those who never tried to quit smoking.

We also noticed that the percentage of young people in the group of non-smokers is high. Most of them have not started smoking yet. Moreover, they are still students. Considering this observation, we decided to investigate the relationship between education and smoking only for adults and elderly people.

Regarding the comparison between non-smokers and smokers, we found that tobacco consumption is higher among men and non-Caucasians. The percentage of smokers is also higher in the group of workers and heads of family, probably due to their greater responsibility and, therefore, to the fact that they live more stressful lives. On average, the per

capita household income of smokers is lower. Finally, note that the number of smokers is higher in households of smokers. As expected, the group of smokers is the most exposed to cigarette ads. It is noteworthy that the average consumption of cigarettes among smokers is of approximately 12 cigarettes a day.

Figure 1 shows the level of education according to the groups. Education is clearly higher in the population of non-smokers. We also observed that there is no clear difference between smokers and ex-smokers in terms of their level of education. This fact reinforces our hypothesis that education is a determinant of the decision to smoke or not to smoke. Additionally, nothing can be said about the relationship between education and the decision to stop smoking or attempt to quit smoking.

Table 3: Average characteristics of the non-smokers, smokers, ex-smokers and those who attempt to quit smoking

| **Characteristics** | **Non-smokers** | | **Smokers** | | **Ex-smokers** | | **Attempt to quit** | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. dev. | Mean | Std. dev. | Mean | Std. dev. | Mean | Std. dev. |
| `Income (ln)` | 6.044 | 1.010 | 5.875 | 1.015 | 6.075 | 1.013 | 5.793 | 1.012 |
| `Works` | 0.658 | 0.474 | 0.732 | 0.443 | 0.619 | 0.486 | 0.751 | 0.433 |
| `Young` | 0.389 | 0.487 | 0.210 | 0.407 | 0.122 | 0.327 | 0.245 | 0.430 |
| `Adult` | 0.487 | 0.500 | 0.646 | 0.478 | 0.583 | 0.493 | 0.647 | 0.478 |
| `Elderly` | 0.124 | 0.329 | 0.144 | 0.351 | 0.295 | 0.456 | 0.108 | 0.311 |
| `Man` | 0.400 | 0.490 | 0.605 | 0.489 | 0.542 | 0.498 | 0.549 | 0.498 |
| `White` | 0.485 | 0.500 | 0.428 | 0.495 | 0.470 | 0.499 | 0.411 | 0.492 |
| `Householder` | 0.443 | 0.497 | 0.635 | 0.482 | 0.668 | 0.471 | 0.622 | 0.485 |
| `Smokers (%)` | 0.052 | 0.128 | 0.115 | 0.179 | 0.058 | 0.137 | 0.102 | 0.168 |
| `Warning` | 0.973 | 0.163 | 0.939 | 0.239 | 0.971 | 0.168 | 0.979 | 0.143 |
| `Marketing` | 0.394 | 0.489 | 0.427 | 0.495 | 0.361 | 0.480 | 0.471 | 0.499 |
| `Urban` | 0.862 | 0.345 | 0.802 | 0.399 | 0.842 | 0.365 | 0.822 | 0.383 |
| `Metropolis` | 0.385 | 0.487 | 0.372 | 0.483 | 0.363 | 0.481 | 0.333 | 0.472 |
| `Cigarettes smoked` | – | – | 12.149 | 6.811 | – | – | 11.292 | 6.723 |
| `N. obs.` | 22967 | | 3444 | | 6713 | | 2477 | |

Source: Prepared by the authors using data from the PETab survey.

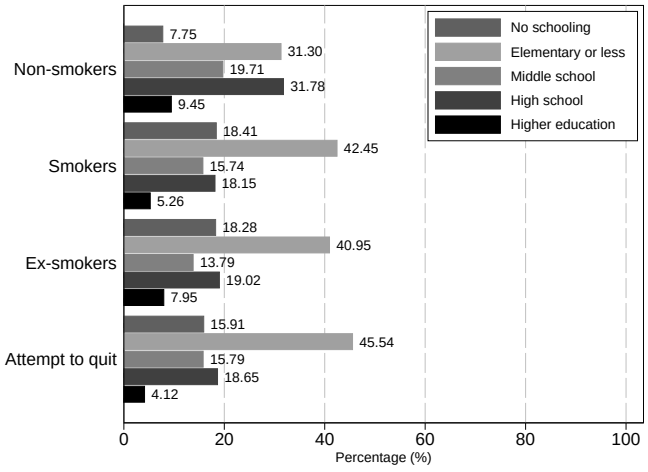


Figure 1: The relationship between smoking and level of schooling.

Source: Prepared by the authors using data from the PETab survey.

*3.2. Empirical procedures*

Initially, to model the decision to smoke, we used the structure of an *Additive Random Utility Model*. From this perspective, we treated the decision to smoke as two possibilities of individual choice: to smoke (1) or not to smoke (0). Thus, following Cameron and Trivedi (2005), the utility of each choice can be written as

$$U_0 = V_0 + \varepsilon_0$$
$$U_1 = V_1 + \varepsilon_1$$

where $U_0$ and $U_1$ are the utilities when an individual decides to smoke or not to smoke, respectively. $V_0$ and $V_1$ represent the deterministic components and $\varepsilon_0$ and $\varepsilon_1$ represent the random components of those utilities. In this regard, the individual will choose the option providing the greater utility. Then, $Y = 1$ if $U_1 > U_0$ will be observed. The probability of observing this result is given by

$$\begin{aligned}\Pr[y = 1] &= \Pr[U_1 > U_0] \\ &= \Pr[V_1 + \varepsilon_1 > V_0 + \varepsilon_0] \\ &= \Pr[\varepsilon_0 - \varepsilon_1 < V_1 - V_0] \\ &= F(V_1 - V_0)\end{aligned}$$

where $F$ is the cumulative distribution function of $\varepsilon_0 - \varepsilon_1$. It should be noted that if $V_0 = x'\beta_0$ and $V_1 = x'\beta_1$, it will only be possible to identify $(\beta_1 - \beta_0)$. This means that it is not possible to check how a certain characteristic affects the utility of a choice, but how a certain characteristic affects the difference in utility provided by choices can be checked.

To make their decisions, rational individuals usually weigh the costs and benefits of their options and, in this case, it can be inferred that people weigh the costs and benefits of smoking. Assuming that this cost-benefit analysis $F(V_1 - V_0)$ is a function of socioeconomic and demographic characteristics, we have $F(V_1 - V_0) = F(X'\beta)$, where $X$ is the vector of those socioeconomic and demographic characteristics. Based on the assumption that $F(\cdot)$ is a normal function, the probability of observing an individual who smokes ($Y = 1$) can be written as follows

$$\Pr(y = 1 \mid X) = \Phi(X'\beta)$$

Once the process involved in the individual choice of smoking or not was investigated, we began to investigate the determinants of the addiction intensity, i.e. the amount of cigarettes smoked a day. Therefore, it is essential to consider the fact that the amount of cigarettes consumed is in part determined by the decision of an individual to smoke or not, meaning that a self-selection process is involved.

A common approach is that of using a bivariate sample selection model in which a latent variable $y_{1i}^*$ determines both the decision of the individual $Y_{1i}$ and the amount of cigarettes

consumed $Y_{2i}$. The selection equation is given by

$$Y_{1i} = \begin{cases} 1 & \text{if } y_{1i}^* > 0 \\ 0 & \text{if } y_{1i}^* \leq 0 \end{cases}$$

and the consumption equation is given by

$$Y_{2i} = \begin{cases} y_{2i}^* & \text{if } y_{1i}^* > 0 \\ - & \text{if } y_{1i}^* \leq 0 \end{cases}$$

According to this approach, $Y_{2i}$ is only observed if $y_{1i}^* > 0$ and it does not assume any value when $y_{1i}^* \leq 0$. Usually, a linear model with additive errors for the latent variables is specified

$$y_1^* = X_1^{'}\beta_1 + \varepsilon_1$$
$$y_2^* = X_2^{'}\beta_2 + \varepsilon_2$$

If there are strong indications of non-correlation between the terms of the two equations above, applying an estimator obtained by OLS in the second equation would be consistent. However, the hypothesis that there are no observable characteristics influencing both the decision to smoke and the amount of cigarettes consumed cannot be refuted. In this case, it is a usual procedure to estimate by OLS the following model for the values of $Y_2$

$$y_{2i} = X_2^{'}\beta_2 + \sigma_{12}\lambda(X_1^{'}\widehat{\beta}_1) + \upsilon_1$$

where $\upsilon_1$ is the error term, $\sigma_{12}$ is the correlation between the errors and $\lambda(X_1^{'}\widehat{\beta}_1) = \phi(X_1^{'}\widehat{\beta}_1)/\Phi(X_1^{'}\widehat{\beta}_1)$ is the inverse Mills ratio obtained by estimating a *probit* model of $y_1$ in $X_1$.

Alternatively, the number of cigarettes consumed can be modeled from the perspective of a counting process. That is, we assume that the number of cigarettes consumed follows a Poisson distribution $\Pr[Y = y] = \frac{e^{-\mu}\mu^y}{y!}$, where $\mu$ is the mean and $y = 0, 1, 2, ..., n$. However, this distribution will only be appropriate under the equidispersion property, i.e. $E[Y] = V[Y] = \mu$. In the presence of overdispersion, the process is best modeled by a Negative Binomial distribution, where $E[y \mid \mu, \alpha] = \mu$ e $V[y \mid \mu, \alpha] = \mu(1 + \alpha\mu)$.

In addition, an excessive amount of zeros must be considered in a counting process. In the case of the amount of cigarettes, there are a lot of zeros due to non-smokers. Then, it is advisable to model the decision process in two stages as

$$f(y) = \begin{cases} f_1(0) & \text{if } y = 0 \\ \frac{1-f_1(0)}{1-f_2(0)} f_2(y) & \text{if } y \leq 1 \end{cases}$$

In this approach, known as *Hurdle Model*, the two parts are functionally independent. According to Cameron and Trivedi (2009), this hypothesis can be relaxed if it can be assumed that zero can occur either as a decision process or as a counting process, as in the following distribution

$$f(y) = \begin{cases} f_1(0) + \{1 - f_1(0)\} f_2(0) & \text{if } y = 0 \\ \{1 - f_1(0)\} f_2(y) & \text{if } y \leq 1 \end{cases}$$

Therefore, given that the amount of cigarettes $f(y)$ is a process such as that described in the equation above, the effect of a particular characteristic of an individual, if there is equidispersion, is calculated through a *poisson* regression with inflated zeros. Otherwise, the most appropriate procedure is to admit that the decision process follows a normal distribution and that $f_2(\cdot)$ has a negative binomial distribution. In this case, the estimation is done using a zero-inflated negative binomial (ZINB) model.

So both the probit model and the first stage of the selection model will be used for us to investigate the decision to smoke, while the second stage of the sample selection model and the count model are intended to analyze the intensity of cigarette consumption.

Regarding the sample selection model, parameter $\rho$ was significant at 1%, i.e. we reject the hypothesis that the two equations are independent. In the count models, in turn, at a significance level of 1% we reject the equidispersion hypothesis ($V[y \mid x] = E[y \mid x]$). Next, the Vuong test showed that a zero inflation is indeed observed and, therefore, that the ZINB models are preferable.

Table 4 shows the marginal effects estimated by gender for each model, with the observation that for the sample selection models we computed the marginal effect of both the first and the second stage on the censored average[6]. Therefore, the first two columns show the effect of the variables on the decision to smoke. The last two columns show in turn the effect on the number of cigarettes consumed per day.

Note that the marginal effect estimated for the regressor set that was used is very similar in both the analysis of the decision to smoke and in the analysis of the intensity of addiction, regardless of the modeling strategy. For the some part, marginal effects were statistically significant and showed the expected direction. But it should be noted that there are some differences between genders.

## 4. Results

As seen in the previous subsection, the results were little sensitive to the modeling strategy that was used. This goes for both the analysis of the determinants of the decision to smoke and for the analysis of the determinants of the amount of cigarettes smoked daily.

Based on the estimations that were done, we sought to answer the following questions. What are the socioeconomic characteristics associated with the decision to smoke and with the intensity of cigarette consumption? What role does education play in relation to tobacco addiction? The assumptions that guided this study so far, as listed in Section 1, are the following ones: "*education reduces the probability of an individual being a smoker*" and "*education reduces the intensity of tobacco use if the individual is a smoker*".

However, a difference between the effect by gender deserves mention. As can be seen, the education effect is stronger for men than for women. In addition, being aware of risks doesn't affect neither the decision to smoke or not to smoke nor the intensity of the smoking habit for women. But for men this variable has a strong effect on both decisions.

[6]For more details, see Hoffmann and Kassouf (2005)

Table 4: Average Marginal Effects of Socioeconomic Characteristics on Tobacco Addiction

| Variables | Women (n = 9865) | | | | Men (n = 6895) | | | |
|---|---|---|---|---|---|---|---|---|
| | Probit model | Selection Model $1^{st}$ stage | Selection Model $2^{nd}$ stage | ZINB model | Probit model | Selection Model $1^{st}$ stage | Selection Model $2^{nd}$ stage | ZINB model |
| Level of Education | | | | | | | | |
| `Elementary or less` | −0.053*** | −0.046*** | −0.642*** | −0.446** | −0.085*** | −0.085*** | −0.883** | −0.784** |
| | (0.015) | (0.014) | (0.215) | (0.192) | (0.023) | (0.023) | (0.441) | (0.341) |
| `Middle school` | −0.050*** | −0.043*** | −0.620** | −0.467** | −0.135*** | −0.135*** | −1.668*** | −1.407*** |
| | (0.018) | (0.017) | (0.257) | (0.225) | (0.028) | (0.028) | (0.528) | (0.406) |
| `High school` | −0.095*** | −0.086*** | −1.209*** | −1.021*** | −0.221*** | −0.221*** | −3.203*** | −2.702*** |
| | (0.016) | (0.015) | (0.232) | (0.205) | (0.025) | (0.025) | (0.469) | (0.361) |
| `Higher education` | −0.092*** | −0.086*** | −1.211*** | −1.036*** | −0.228*** | −0.228*** | −3.474*** | −2.824*** |
| | (0.019) | (0.017) | (0.263) | (0.228) | (0.030) | (0.030) | (0.536) | (0.417) |
| `Warning` | −0.068** | −0.046* | −0.608* | −0.073 | −0.135*** | −0.135*** | −2.267** | −1.725** |
| | (0.028) | (0.024) | (0.365) | (0.251) | (0.045) | (0.045) | −1111 | (0.708) |
| `Income (ln)` | −0.006 | −0.005 | −0.052 | 0.005 | −0.014* | −0.014* | 0.222 | 0.036 |
| | (0.005) | (0.004) | (0.066) | (0.057) | (0.008) | (0.008) | (0.163) | (0.115) |
| `Works` | 0.003 | 0.003 | −0.032 | −0.035 | 0.020 | 0.020 | 0.185 | 0.304 |
| | (0.008) | (0.008) | (0.114) | (0.102) | (0.018) | (0.018) | (0.365) | (0.260) |
| `Elderly` | −0.064*** | −0.065*** | −0.951*** | −0.859*** | −0.009 | −0.009 | −0.622* | −0.385 |
| | (0.007) | (0.007) | (0.100) | (0.089) | (0.020) | (0.020) | (0.371) | (0.282) |
| `White` | −0.018** | −0.015* | −0.177 | −0.033 | −0.019 | −0.019 | −0.430* | −0.257 |
| | (0.008) | (0.007) | (0.110) | (0.093) | (0.014) | (0.014) | (0.255) | (0.191) |
| `Householder` | 0.053*** | 0.055*** | 0.827*** | 0.660*** | 0.019 | 0.019 | 0.041 | 0.133 |
| | (0.008) | (0.008) | (0.124) | (0.104) | (0.016) | (0.016) | (0.303) | (0.230) |
| Smokers (%) | 0.285*** | 0.268*** | 3.817*** | 3.405*** | 0.647*** | 0.648*** | 11.070*** | 8.801*** |
| | (0.021) | (0.020) | (0.295) | (0.269) | (0.050) | (0.050) | (0.916) | (0.690) |
| `Marketing` | 0.032*** | 0.028*** | 0.417*** | 0.339*** | 0.046*** | 0.046*** | 1.049*** | 0.814*** |
| | (0.008) | (0.008) | (0.117) | (0.102) | (0.013) | (0.013) | (0.264) | (0.199) |
| `Urban` | −0.001 | 0.005 | 0.101 | 0.194* | −0.029* | −0.029* | −0.431 | −0.205 |
| | (0.010) | (0.009) | (0.132) | (0.117) | (0.018) | (0.018) | (0.352) | (0.251) |
| `Metropolis` | 0.011 | 0.015* | 0.173 | 0.251** | 0.000 | 0.000 | 0.308 | 0.249 |
| | (0.008) | (0.008) | (0.114) | (0.101) | (0.014) | (0.014) | (0.284) | (0.217) |
| `North` | −0.044*** | −0.048*** | −0.743*** | −0.313*** | −0.012 | −0.012 | −0.942* | −0.647*** |
| | (0.014) | (0.013) | (0.188) | (0.086) | (0.026) | (0.026) | (0.496) | (0.207) |
| `Northeast` | −0.039*** | −0.038*** | −0.576*** | −0.175** | −0.004 | −0.004 | −0.585 | −0.409*** |
| | (0.012) | (0.011) | (0.169) | (0.068) | (0.020) | (0.020) | (0.400) | (0.143) |
| `Southeast` | −0.024** | −0.022** | −0.316* | −0.054 | −0.004 | −0.004 | −0.504 | −0.215 |
| | (0.011) | (0.010) | (0.162) | (0.057) | (0.018) | (0.018) | (0.368) | (0.133) |
| `Midwest` | −0.043*** | −0.036*** | −0.573*** | 0.071 | −0.023 | −0.023 | −0.351 | 0.003 |
| | (0.013) | (0.013) | (0.194) | (0.085) | (0.023) | (0.023) | (0.490) | (0.176) |

Notes: Standard errors in parentheses; * Significance at 10%; ** Significance at 5%; *** Significance at 1%.

The estimates presented in Table 4 provide strong evidence that investing in human capital, represented here by one's schooling level, tends to reduce both the likelihood of smoking and the intensity of cigarette consumption. Thus, our results support the hypotheses made above.

More educated individuals are on average less likely to smoke, and when they do decide to smoke they tend to consume fewer cigarettes daily. Our estimates indicated that, on average, the probability of smoking declines by about 0.09 percentage points (p.p.) among more educated women and that they tend to smoke about 1 cigarette less per day as compared to uneducated individuals. For more educated men we found a reduction of about 0.23 percentage points in the probability of smoking and that they tend to smoke about 3 cigarettes less per day as compared to uneducated men.

Our evidence corroborates the findings of other studies that we investigated. In Cutler and Lleras-Muney (2006), Kendler et al. (1999), Madden (2008) and (Grimard and Parent, 2007) evidence is also provided that years of schooling have a negative effect on the likelihood of smoking. However, after controlling for endogeneity between years of schooling and smoking, (Koning et al., 2015) found no statistically relevant relationship between education and the decision to smoke. Regarding the amount of cigarettes smoked, both Cutler and Lleras-Muney (2006), and De Walque (2007) provide evidence similar to the one provided here.

Therefore, it can be inferred that the effect of education on smoking behavior can be described as follows: (i) higher levels of education affect the way individuals think and make decisions (Cutler and Lleras-Muney, 2006), (ii) education prevents people from adopting behaviors that can be harmful to their health in the future (Koning et al., 2015) and (iii) lead to a better understanding of the costs associated with smoking.

The specialized literature acknowledges the robust relationship between education and health. Our estimates are in line with those done in other empirical studies, since the albeit not causal relationship between education and health is expressed here by the negative effect of the level of education on tobacco addiction.

As for the other controls, another gender difference was related to age and race/color. It should be noted that older women are less likely to be smokers than younger women. For men, there is no difference regarding this variable. Caucasian women are less likely to smokers while among men this difference isn't statistically significant.

We also observed that the higher the household income, the lower the probability of an individual smoking. Its effect on the intensity of tobacco addiction is negative. On average, being the family head is also a factor that increases both the probability of smoking and the number of cigarettes consumed per day only for women.

As the percentage of smokers in a household increases, the risk of an individual being a smoker increases by approximately 0.27 p.p. and 0.64 p.p., while the amount of cigarettes smoked increases by 4 and 10 units for women and men, respectively. This result corroborates the findings of the previous literature. Analyses conducted with adolescents in the 10-20 age bracket and even with older smokers show that most of them have relatives who also smoke. This relationship is one of the most influential risk factors for the onset of smoking. The effects can be even stronger for young people from low-income families and young parents

with low education, factors that can lead to persistent family cycles (or cycle of deprivation) throughout one's life as a smoker[7].

Information on the risks of smoking and of being exposed to tobacco ads consist in variables with high statistical significance and expected sign only for men.That is, the more information, the lower the probability of smoking and the lower the amount of cigarettes consumed. For women, this effect is only felt in the probability of being a smoker. It is to be expected that rational individuals avoid risky behaviors. This effect can occur through two channels. The first one would be through education, i.e. the more educated individuals are, the better they understand the health risks posed by tobacco use. The second one would be through access to information, i.e. individuals with access to information or who seek information are more likely to use it in connection with their decision to smoke or not to smoke.

In order to corroborate this hypothesis, we interacted the variable risk with level of education and then we estimated the average marginal effect of the risks on the probability of smoking and on the number of cigarettes smoked for people falling under each education level. According to Table 5, we could not find any clear pattern regarding the effect of the risk variable for people falling under each education level. Notwithstanding these results, we cannot infer that this channel is not important. This could be only a limitation of our estimations that fail to take into account the endogeneity between smoking and education.

With regard to advertising, its estimated effect was as expected and more pronounced for men. The variable indicating exposure to any tobacco advertising strategies has a positive sign and high statistical significance both for the decision to smoke and for the number of cigarettes consumed per day.

## 5. Concluding remarks

In this paper, we investigate the relationship between education and smoking in Brazil. For this purpose, we use a national database (PETab) that makes it possible for a wide range of information related to smoking behavior to be used.

We conducted this analysis by modeling the decision to smoke and also the amount of cigarettes smoked per day. We therefore estimated a *probit*model, a sample selection model and a count model (ZINB). Despite the different modelling strategies adopted, the results were very similar. We also take into account gender differences.

Although our results cannot be interpreted as indicating a causal relationship, the evidence found in this study, besides consistent with those found in the literature, suggests that more educated individuals are less likely to smoke and that when they do smoke they tend to consume fewer cigarettes per day. This result was more pronounced for men compared to women. This suggests that education may be the right path for controlling and reducing smoking in Brazil. In addition to making a more informed decision in relation to smoking

[7]For a more detailed discussion on the relationship between the family environment and smoking see, for example, Hill et al. (2005), Gilman et al. (2009), Williams and Covington (1997) and Avenevoli and Merikangas (2003)

Table 5: Average marginal effects of the information about risks of tobacco addiction by level of education and by gender

| Variables | Probit model | Selection Model $1^{st}$ stage | Selection Model $2^{nd}$ stage | ZINB model |
|---|---|---|---|---|
| **Women level of education** | | | | |
| `No schooling` | −0.146*** | −0.092 | −0.630 | −0.619 |
| | (0.055) | (0.058) | (0.741) | (0.714) |
| `Elementary or less` | −0.156*** | −0.142*** | −1.922* | −1.191 |
| | (0.051) | (0.054) | (1.058) | (0.734) |
| `Middle school` | −0.114 | −0.061 | −0.341 | −0.601 |
| | (0.083) | (0.085) | (1.198) | (1.188) |
| `High school` | 0.049*** | 0.074*** | 1.217*** | 1.004*** |
| | (0.013) | (0.024) | (0.202) | (0.189) |
| `Higher education` | −0.305** | −0.287** | −0.075 | −0.777 |
| | (0.136) | (0.142) | (0.516) | (0.672) |
| **Men level of education** | | | | |
| `No schooling` | −0.100 | −0.045 | −1.788 | −1.419 |
| | (0.064) | (0.061) | (1.557) | (1.024) |
| `Elementary or less` | −0.078 | −0.050 | −0.185 | −0.054 |
| | (0.061) | (0.058) | (1.042) | (0.846) |
| `Middle school` | 0.073 | 0.124 | 2.388* | 1.547 |
| | (0.081) | (0.083) | (1.391) | (1.226) |
| `High school` | −0.293** | −0.220* | −5.922 | −3.540 |
| | (0.120) | (0.120) | (4.552) | (2.293) |
| `Higher education` | −0.263 | −0.256 | −1.801 | −2.566 |
| | (0.177) | (0.173) | (3.102) | (2.836) |

Notes: $N$ =; Standard errors in parentheses; * Significance at 10%; ** Significance at 5%; *** Significance at 1%.

or not, more educated individuals avoid risky behaviors and are better prepared to evaluate the costs and benefits of their actions.

In order to investigate whether the link between smoking and education was determined by better use of information on the risks of smoking behavior, we interacted the level of education with the variable that captures knowledge about the risks of smoking behavior. However, our results have not shown a clear pattern to corroborate the previous hypothesis.

Among other regressors used in our analysis, special mention should be made of exposure to cigarette ads. Perhaps as never done before, we describe the effect of this variable on the decision to smoke and on the amount of cigarettes consumed daily. The estimated and statistically significant marginal effects presented in this study clearly show that policies for controlling and reducing smoking by controlling cigarette ads are also very likely to be successful.

Although these results provide sufficient inputs for policy makers, there is still room for further investigation. For example, we have not yet investigated the effect of schooling on cessation of addiction, on attempts of cessation of addiction and on the duration of addiction. In addition, it is important to conduct new research with the aim of finding the causal relationship between smoking and education in Brazil.

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## AppendixA.

Table A.1: Estimated Coefficients for Socioeconomic Characteristics related to Tobacco Addiction

| Variables | Women (n = 9865) | | | | | Men (n = 6895) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Probit | Selection Model | | ZINB model | | Probit | Selection Model | | ZINB model | |
| | model | $1^{st}$ stage | $2^{nd}$ stage | $1^{st}$ stage | $2^{nd}$ stage | model | $1^{st}$ stage | $2^{nd}$ stage | $1^{st}$ stage | $2^{nd}$ stage |
| Level of Education | | | | | | | | | | |
| Elementary or less | −0.128 | −0.048 | −0.590 | 0.069 | 0.114 | −0.275 | −0.274 | −0.986 | −0.025 | 0.276 |
| | (0.218) | (0.193) | (4.244) | (0.235) | (0.218) | (0.224) | (0.224) | (3.099) | (0.153) | (0.224) |
| Middle school | −0.255 | −0.209 | −4.062 | 0.089 | 0.247 | −0.915** | −0.915** | −1.946 | 0.008 | 0.926** |
| | (0.320) | (0.281) | (6.264) | (0.324) | (0.326) | (0.374) | (0.374) | (5.341) | (0.258) | (0.374) |
| High school | −1.664*** | −1.591*** | −36.583*** | −1.254*** | 1.599*** | −0.082 | −0.086 | 4.652 | 0.093 | 0.091 |
| | (0.365) | (0.339) | (7.785) | (0.385) | (0.366) | (0.345) | (0.344) | (7.983) | (0.247) | (0.346) |
| Higher education | 0.181 | −0.067 | −1.566 | −0.731*** | −0.156 | −0.177 | −0.178 | −4.305 | −0.084 | 0.185 |
| | (0.395) | (0.269) | (6.000) | (0.210) | (0.404) | (0.490) | (0.490) | (5.224) | (0.367) | (0.491) |
| Warning | −0.501*** | −0.408*** | −8.856*** | 0.141 | 0.516*** | −0.260 | −0.261 | −1.212 | −0.041 | 0.261 |
| | (0.164) | (0.137) | (2.976) | (0.185) | (0.165) | (0.162) | (0.163) | (2.587) | (0.100) | (0.163) |
| Elementary or less × Warning | −0.131 | −0.182 | −4.065 | 0.009 | 0.128 | 0.037 | 0.035 | 2.645 | 0.107 | −0.034 |
| | (0.228) | (0.204) | (4.505) | (0.244) | (0.229) | (0.231) | (0.232) | (3.187) | (0.158) | (0.232) |
| Middle school × Warning | 0.017 | 0.003 | −0.300 | −0.054 | −0.023 | 0.535 | 0.535 | 3.939 | 0.092 | −0.542 |
| | (0.328) | (0.289) | (6.450) | (0.330) | (0.335) | (0.380) | (0.381) | (5.452) | (0.263) | (0.381) |
| High school × Warning | 1.168*** | 1.144*** | 27.089*** | 1.297*** | −1.106*** | −0.684* | −0.681* | −3.712 | −0.076 | 0.679* |
| | (0.371) | (0.345) | (7.864) | (0.388) | (0.372) | (0.349) | (0.349) | (8.071) | (0.255) | (0.351) |
| Higher education × Warning | −0.719* | −0.444 | −9.286 | 0.703*** | 0.702* | −0.619 | −0.618 | 4.269 | 0.083 | 0.615 |
| | (0.403) | (0.278) | (6.211) | (0.223) | (0.412) | (0.495) | (0.495) | (5.366) | (0.371) | (0.495) |
| Income (ln) | −0.034 | −0.029 | −0.465 | 0.043 | 0.021 | −0.048* | −0.047* | 2.054*** | 0.080*** | 0.050* |
| | (0.028) | (0.027) | (0.632) | (0.026) | (0.027) | (0.027) | (0.027) | (0.449) | (0.020) | (0.027) |
| Works | 0.018 | 0.020 | −0.421 | −0.080* | −0.025 | 0.069 | 0.069 | −0.672 | 0.020 | −0.068 |
| | (0.049) | (0.047) | (1.089) | (0.043) | (0.049) | (0.065) | (0.065) | (1.064) | (0.048) | (0.065) |
| Elderly | −0.468*** | −0.472*** | −11.537*** | −0.229*** | 0.463*** | −0.031 | −0.031 | −2.251** | −0.104** | 0.030 |
| | (0.064) | (0.063) | (1.464) | (0.073) | (0.064) | (0.071) | (0.071) | (1.041) | (0.051) | (0.071) |
| White | −0.108** | −0.088** | −1.622 | 0.077* | 0.061 | −0.063 | −0.063 | −0.601 | −0.014 | 0.057 |
| | (0.047) | (0.045) | (1.046) | (0.045) | (0.044) | (0.048) | (0.048) | (0.683) | (0.035) | (0.045) |
| Householder | 0.307*** | 0.314*** | 7.197*** | 0.057 | −0.302*** | 0.064 | 0.065 | −1.264 | −0.040 | −0.065 |
| | (0.044) | (0.043) | (1.042) | (0.043) | (0.044) | (0.055) | (0.055) | (0.913) | (0.043) | (0.055) |
| Smokers (%) | 1.740*** | 1.631*** | 36.219*** | 0.167 | −1.761*** | 2.199*** | 2.201*** | 2.891 | 0.158* | −2.207*** |
| | (0.127) | (0.118) | (2.840) | (0.107) | (0.127) | (0.165) | (0.165) | (1.806) | (0.086) | (0.166) |
| Marketing | 0.186*** | 0.163*** | 3.773*** | −0.025 | −0.192*** | 0.154*** | 0.154*** | 1.399* | 0.077** | −0.154*** |
| | (0.046) | (0.044) | (1.015) | (0.042) | (0.046) | (0.045) | (0.045) | (0.714) | (0.034) | (0.045) |
| Urban | −0.006 | 0.033 | 1.030 | 0.217*** | 0.007 | −0.098* | −0.098* | 0.187 | 0.064 | 0.102* |
| | (0.064) | (0.059) | (1.332) | (0.071) | (0.064) | (0.058) | (0.058) | (0.911) | (0.042) | (0.058) |
| Metropolis | 0.069 | 0.090** | 1.553 | 0.096** | −0.079* | 0.000 | 0.000 | 1.411* | 0.082** | −0.004 |
| | (0.046) | (0.045) | (1.058) | (0.043) | (0.046) | (0.049) | (0.049) | (0.797) | (0.037) | (0.049) |
| North | −0.262*** | −0.294*** | −7.259*** | −0.331*** | | −0.041 | −0.041 | −3.459** | −0.238*** | |
| | (0.090) | (0.084) | (1.928) | (0.097) | | (0.090) | (0.090) | (1.549) | (0.080) | |
| Northeast | −0.227*** | −0.221*** | −5.210*** | −0.172** | | −0.012 | −0.012 | −2.371** | −0.143*** | |
| | (0.067) | (0.064) | (1.467) | (0.067) | | (0.067) | (0.067) | (1.090) | (0.049) | |
| Southeast | −0.131** | −0.120** | −2.566** | −0.050 | | −0.014 | −0.014 | −1.956* | −0.073 | |
| | (0.059) | (0.056) | (1.289) | (0.052) | | (0.061) | (0.061) | (1.028) | (0.045) | |
| Midwest | −0.252*** | −0.206*** | −5.210*** | 0.062 | | −0.078 | −0.078 | 0.254 | 0.001 | |
| | (0.082) | (0.080) | (1.830) | (0.073) | | (0.078) | (0.078) | (1.410) | (0.058) | |
| Constant | −0.331 | −0.526*** | −11.230** | 1.867*** | 0.583*** | 0.004 | 0.003 | 7.094* | 2.061*** | −0.004 |
| | (0.226) | (0.204) | (4.648) | (0.245) | (0.216) | (0.229) | (0.229) | (3.809) | (0.154) | (0.216) |

Notes: Standard errors in parentheses; * Significance at 10%; ** Significance at 5%; *** Significance at 1%.